NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

April 24, 2013

Airworthiness Group Chairman's Factual Report

NTSB No: CEN13FA121

A. ACCIDENT

Operator:	Air Methods
Aircraft:	Eurocopter EC130 B4, Registration N334AM
Location:	Seminole, Oklahoma
Date:	January 2, 2013
Time:	1245 Central Standard Time (CST)

B. AIRWORTHINESS GROUP

Airworthiness Group Chairman:	Chihoon Shin Aerospace Engineer – Helicopters Washington, District of Columbia
Federal Aviation Administration (FAA) Flight Safety District Office (FSDO) Group Member:	Jaime Pagán Aviation Safety Inspector Oklahoma City, Oklahoma
FAA Rotorcraft Directorate Group Member:	Matt Rigsby Accident Investigator Fort Worth, Texas
Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) Accredited Representative:	Emmanuel Delbarre Safety Investigator Le Bourget, France
American Eurocopter (AEC) Group Member:	Seth Buttner Senior Accident Investigator Grand Prairie, Texas
Turbomeca Group Member:	Bryan Larimore Accident Investigator Grand Prairie, Texas

LIST OF ACRONYMS

AEC	American Eurocopter
ALF	Aft Looking Forward
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
CO	Colorado
CST	Central Standard Time
CYA	confirm your aircraft
DC	District of Columbia
DECU	Digital Engine Control Unit
EMS	Emergency Medical Services
F	Fahrenheit
FAA	Federal Aviation Administration
FOD	Foreign Object Debris
FSDO	Flight Safety District Office
HMU	Hydromechanical Unit
IIC	Investigator-in-Charge
KSNL	Shawnee Regional Airport
KSRE	Seminole Municipal Airport
MET	Maintenance Manual (Eurocopter)
METAR	Meteorological Aerodrome Report
MSM	Master Servicing Manual (Eurocopter)
MTC	Standard Practices Manual (Eurocopter)
NTSB	National Transportation Safety Board
OK	Oklahoma
RFMS	Rotorcraft Flight Manual Supplement
RPM	Revolutions-Per-Minute
STC	Supplemental Type Certificate
TX	Texas
W.C.	Work Card (Eurocopter)

C. SUMMARY

On January 2, 2013, about 1245 CST, a Eurocopter EC130 B4 helicopter, registration N334AM and serial number 4694, powered by a single Turbomeca Arriel 2B1 turboshaft engine, experienced a hard landing following a loss of engine power near Seminole, Oklahoma (OK). The pilot and three crewmembers were seriously injured and the helicopter sustained substantial damage. The helicopter, owned and operated by Air Methods Corporation of Centennial, Colorado (CO), was operating under the provisions of 14 *Code of Federal Regulations* Part 91 as a positioning flight. Visual meteorological conditions (VMC) prevailed and a company visual flight rules (VFR) flight plan was filed and activated. The flight departed Seminole Municipal Airport (KSRE) at 1242 CST and was en route to a hospital in Okemah, OK. Shortly after takeoff, the pilot reported a loss of engine power. The pilot performed an autorotation into a field and, during landing, touched down hard. The helicopter remained in an upright position. At 1235 CST, a meteorological aerodrome report (METAR) from Shawnee Regional Airport (KSNL) reported winds from 280 degrees at 8 knots, visibility of 10 miles, a clear sky, temperature of 39° F, dew point of 32° F, and a barometric pressure of 30.25 inches of mercury.

From January 3 – 4, 2013, the Airworthiness Group, consisting of members from the local FAA FSDO, AEC, Turbomeca, and the NTSB, convened at the site of the accident and performed an examination of the helicopter. The examination revealed the helicopter sustained significant damage to the main rotor head and main rotor blades; a separation of the tailboom and Fenestron[1] from the main fuselage; and severe deformation of the landing skids. The air filter and air intake duct exhibited no signatures of damage, blockages, or foreign object debris (FOD) on either side. Removal of the air intake duct revealed significant deformation damage on four axial compressor blades on the outboard tips of their leading edges; the deformation was observed to be in the direction opposite of normal rotation consistent with ingestion of soft body FOD, such as ice. The engine was removed from the helicopter and shipped to Turbomeca's facility in Grand Prairie, Texas (TX).

On January 30, 2013, the NTSB IIC, representatives from Air Methods, and Airworthiness Group members from the FAA Rotorcraft Directorate, Turbomeca, and AEC convened at Turbomeca in Grand Prairie, TX to perform an engine run and a readout of the Digital Engine Control Unit (DECU). After replacement of the original hydromechanical unit (HMU), the engine operated normally to approximately 100% revolutions-per-minute (RPM).

D. DETAILS OF THE INVESTIGATION

1.0 AIRCRAFT INFORMATION

The Eurocopter EC130 B4 helicopter has a three-bladed main rotor system[2] that provides helicopter lift and thrust. A 10-bladed Fenestron tail rotor system provides anti-torque and directional yaw control. The helicopter is equipped with one Turbomeca Arriel 2B1 turboshaft engine. On the accident helicopter, Air Methods had replaced the standard engine air intake filter with a FDC/aerofilter inlet barrier filter system under Supplemental Type Certificate (STC) SR01373SE.

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[1] The Fenestron tail rotor design consists of a multi-bladed tail rotor shrouded by the helicopter's vertical stabilizer/fin.

[2] Eurocopter main rotor blades rotate in a clockwise direction when looking down at the main rotor disc from birds-eye view. Thus when seated in the pilot's seat, the main rotor blade tips will traverse from left to right. In this report, the terms "left" and "right" are used when in the frame of reference of looking forward from the aft end of the aircraft, i.e. aft looking forward (ALF).

The Starflex, a three-armed star-shaped composite structure that is bolted to the top main rotor shaft, attaches to three rotor blade sleeve assemblies. Each sleeve assembly consists of an upper and lower sleeve and contains an elastomeric thrust bearing at the inboard end (closest to the Starflex hub) and a spherical bearing installed in a frequency damper at the outboard end (near the blade attaching end). A pitch horn is mounted to the inboard end of the lower sleeve. Each main rotor blade is secured to the outboard end of the sleeve assembly via two blade attachment pins.

The aircraft's cyclic, collective, and anti-torque/directional yaw inputs from the cockpit are transferred to the main and tail rotors through a system of pushrods and bellcranks; the main rotor controls are hydraulically-assisted with a total of three servo-controls and the tail rotor is controlled with a mechanical tail rotor flex ball cable. The three main rotor servo-controls consist of the left-roll, right-roll, and fore-aft servo-controls. The actuation of the fore-aft or of the left-roll and right-roll servo-controls provides cyclic pitching of the main rotor blades. The actuation of all three actuators in unison provides collective pitching of the main rotor blades.

The aircraft's main fuselage structure supports the cockpit, passenger cabin, engine, main transmission system, fuel tanks, and landing skids. The tailboom is attached to the rear section of the main fuselage and carries with it the tail rotor drive system, the horizontal stabilizer, and the Fenestron. Aircraft N334AM was configured with an emergency medical services (EMS) interior with 1 pilot (seated on the left side of the cockpit), 3 seats in the passenger cabin, and 1 stretcher spanning from the passenger cabin to the cockpit.

The Turbomeca Arriel 2B1 turboshaft engine is a self-contained engine with a 2-stage compressor (1 axial and 1 centrifugal), an annular combustor, a single-stage gas generator turbine, and a single-stage power turbine. The compressor and turbine stages rotate counter-clockwise when in the ALF frame of reference. Reduction gears connected to the power turbine drive the engine output shaft.

2.0 WRECKAGE DOCUMENTATION AT THE ACCIDENT SITE

The Airworthiness Group, comprised of members from AEC, Turbomeca, the local FAA FSDO, and the NTSB, convened at the accident site in Seminole, OK from January 3 – 4, 2013 to perform documentation of the aircraft and the accident site. The aircraft came to rest upright on a magnetic heading of 262 degrees. The Fenestron had separated from the aircraft and was found approximately 30 feet north of the main wreckage (**Photo 1**). Three primary ground scars near to the aircraft's final resting position were identified as those consistent with contact from the single tail skid and the two landing skids. The location of the ground scars relative to the final resting position of the aircraft was consistent with a clockwise rotation of the aircraft of approximately 180 degrees following initial ground impact of the landing skids and the tail skid (**Photo 2**). A barbed-wire fence was located approximately 16 feet west of the single tail skid ground scar and approximately 54 feet west of the main wreckage.

Photo 1. The accident scene with the separated Fenestron seen in the foreground.

Photo 2. Ground scars observed relative to the aircraft.

2.1 MAIN ROTOR SYSTEM

The main rotor system consists of the main transmission system, main rotor shaft, main rotor head, and the main rotor blades. The three main rotor blades are color coded 'red', 'blue', and 'yellow'. The main rotor blade colors follow the sequence of 1) 'blue', 2) 'red', and 3) 'yellow' when turning in the clockwise direction.

2.1.1 MAIN ROTOR BLADES

All three main rotor blades remained attached to the main rotor head. The red main rotor blade exhibited trailing edge separation adjacent to the blade cuff. The damage along various points on the leading edge of the 'red' main rotor blade matched that of a 45° straight-lined impact mark to the tailboom and engine exhaust duct on the right side of the aircraft (**Photo 3**). The 'blue' main rotor blade exhibited impact damage on the bottom of the blade approximately 50 inches from the blade tip end; light blue paint transfer marks were observed on some of the edges of the damaged area. The 'blue' main rotor blade also exhibited trailing edge separation along various points of the entire length of the blade. The tip of the 'blue' main rotor blade exhibited damage that was matched to damage found on the Fenestron stators. The 'yellow' main rotor blade exhibited an area of damage on its trailing edge, beginning from 51 inches from the blade tip and extending approximately 58 inches inboard. Light blue paint transfer marks were observed on the bottom side of the blade at approximately 6 inches from the tip end of the 'yellow' main rotor blade and extended inboard approximately 46 inches. Blue paint transfer marks were observed on the leading edge of the 'yellow' main rotor blade, beginning from 32 inches from the blade tip extending approximately 4 inches inboard.

Photo 3. Straight-lined impact damage seen on the tailboom and engine exhaust.

2.1.2 MAIN ROTOR HEAD AND MAIN ROTOR SHAFT COMPONENTS

The Starflex remained attached to the main rotor shaft. The vibration absorber and upper shroud remained installed on the Starflex. The tip-end of the 'red' main rotor blade Starflex arm was not connected to the ball joint within the elastomer block located at the outboard end of the sleeve assembly (**Photo 4**). No evidence of fractures was observed on the 'red' Starflex arm. The 'blue' and 'yellow' main rotor blade Starflex arm exhibited fractures approximately midway outboard of the Starflex arm flexure point; the fractures were relatively perpendicular to the arm (**Photo 4**). Both 'blue' main rotor blade sleeve assemblies were fractured and twisted consistent with lateral overstress forces. All three main rotor blade pitch change rods (PCR) remained installed to their respective pitch horns and the rotating swashplate with no evidence of substantial damage to the pitch horn and the PCRs.

The rotating and stationary swashplates, and their associated scissor link assemblies, exhibited no evidence of substantial damage. All three main rotor servo-controls (left-hand roll, right-hand roll, and fore-aft) remained attached to both the stationary swashplate and the main transmission upper housing. The inputs control rods remained installed to the main rotor servo-controls. The hydraulic lines to the servo-controls remained installed; no evidence of excessive leakage of hydraulic fluid from the hydraulic lines was found.

Photo 4. Damage seen on the 'red', 'yellow', and 'blue' Starflex arms.

2.1.3 MAIN TRANSMISSION

All four main transmission suspension bars remained installed between the main transmission housing and the airframe and exhibited no visual cracks or fractures. No indications of binding or seizing of the transmission system were observed when the main rotor head was turned by hand. The hydraulic pump belt drive and pulley exhibited no evidence of damage or excessive wear. The freewheel unit exhibited no evidence of binding when rotated by hand in the direction opposite of normal drive.

2.2 TAIL ROTOR SYSTEM

The forward tail rotor drive shaft remained attached to the engine output flange via the forward flexible coupling with all attaching hardware installed. The flanges from both the tail rotor drive shaft and engine output shaft, as well as the flexible coupling in between the flanges, exhibited axial warping consistent with the separation of the tailboom from the main fuselage at that location. The engine output drive shaft's aft flange and aft flexible coupling exhibited rub marks on its outer edges. The aft flexible coupling exhibited minor warping. The splined coupling between the tail rotor drive shafts exhibited no signatures of major wear or degradation.

The tail rotor drive shaft had fractured in two locations while the Fenestron drive shaft had fractured in one location (**Photo 5**). The first break was approximately 36 inches aft of the forward splined connection to the engine output shaft. The second break was approximately 36 inches aft of the first break. The remainder of the tail rotor drive shaft remained continuous for another 48 inches until the last break at the Fenestron drive shaft. All drive shaft hanger bearings were accounted for and exhibited no evidence of seizure when turned by hand. All observed fracture surfaces exhibited signatures consistent with overload.

The flexible coupling from the Fenestron drive shaft to the tail gear box exhibited signatures of warping. Fenestron blades showed no evidence of rotational damage. Scuff marks in the path of tail rotor blade tip travel was observed on the Fenestron shroud adjacent to the blades, with a significant scuff mark found near the 6 o'clock position of the Fenestron (**Photo 6**). Three Fenestron stators exhibited impact damage that was matched to impact damage found on the tip of the 'blue' main rotor blade (**Photo 7**).

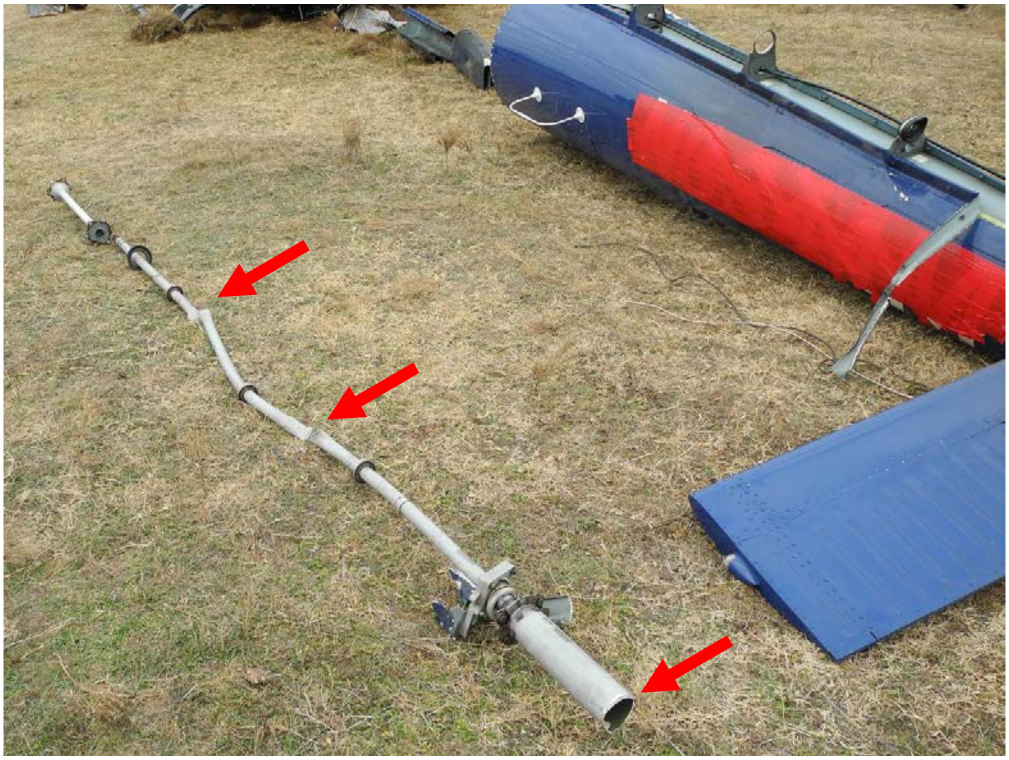

Photo 5. The Fenestron drive system reconstructed after removal from the helicopter. The upper two arrows mark the breaks in the tail rotor drive shaft and the lower arrow marks the break in the Fenestron drive shaft.

Photo 6. A significant scuff mark found on the Fenestron shroud.

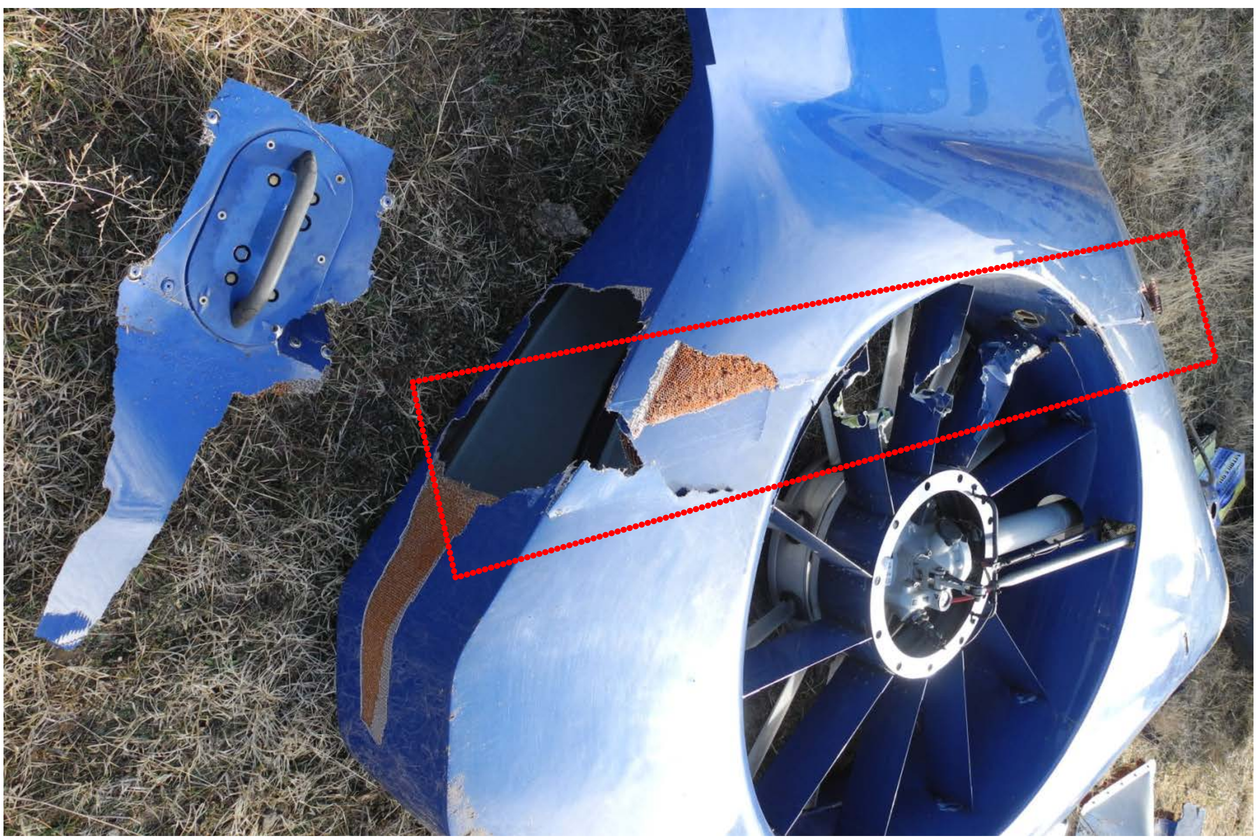

Photo 7. 'Blue' main rotor blade impact mark seen on the Fenestron.

2.3 FLIGHT CONTROL SYSTEMS

The pilot-side flight controls were the only set of flight controls installed inside the cockpit. Movement of the cyclic and collective control sticks showed no evidence of binding. Continuity of the flight controls from the pilot's control sticks to the stationary swashplate of the main rotor head was confirmed via movement of the cyclic and collective control sticks. Movement of the pedals resulted in a corresponding movement of the tail rotor pitch control cable at the tailboom fracture location. There were no leaks observed on the hydraulic system.

2.4 ENGINE AND AIR INTAKE

The air filter installed was observed to be the FDC/aerofilter air inlet barrier filter system. The air filter showed no evidence of major damage. No blockages or large pieces of FOD were observed on either side of the air filter (**Photos 8 and 9**). The air intake duct remained attached to the engine and showed no evidence of cracks or fractures. The drain hole in the air intake duct showed no evidence of blockages.

The engine remained installed on the airframe. The engine's fuel, oil, and electrical connections remained intact. The presence of fuel in the engine's HMU was confirmed. A sample of fuel was tested for the presence of water; the fuel exhibited no suspended water. Removal of the air intake duct exposed the axial compressor (the first stage of compression). Four axial compressor blades exhibited significant deformation on the outboard tips of their leading edges; the deformation was observed to be in the direction opposite of normal rotation (**Photo 10**). Deformation observed on the four axial compressor blades was consistent with ingestion of soft body FOD. Ice is an example of soft body FOD. The power turbine blades were observed to be undamaged (**Photo 11**).

The exhaust duct remained installed on the aft end of the engine and exhibited impact damage on its right side in line with impact damage seen on the tailboom. This impact mark was matched to damage found on the red main rotor blade's leading edge. The engine was removed from the aircraft for further examination (see Section 3.0 of this report).

2.5 AIRCRAFT STRUCTURES

The main fuselage and tailboom remained adjacent to each other at the final resting location of the aircraft. The tailboom had separated from the main fuselage. The Fenestron, separated from the tailboom, was found lying on the ground with its left side (tail rotor side) facing upwards.

2.5.1 MAIN FUSELAGE AND LANDING SKIDS

The main fuselage exhibited no signatures consistent with fracturing prior to ground impact. The landing skids remained attached to the main fuselage. The aft-left corner of the landing skid was observed to have dug itself into the ground. The landing skids exhibited significant deformation consistent with a hard impact to the ground (**Photo 12**).

Photo 8. The outside surface of the FDC/aerofilter installed on the aircraft.

Photo 9. The underside of the air filter (left) and the air intake duct (right).

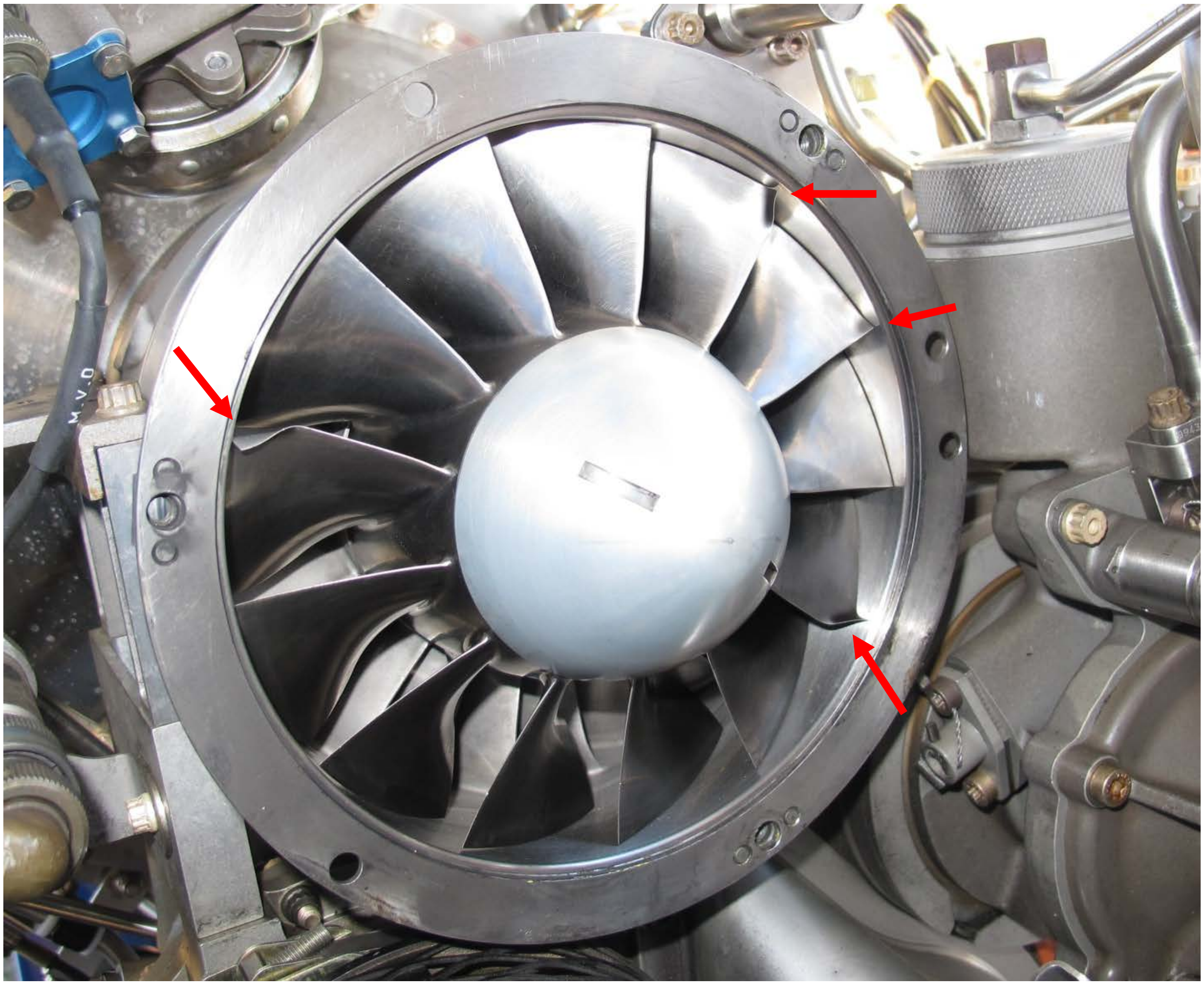

Photo 10. Deformation found on the first-stage axial compressor blades.

Photo 11. The power turbine blades (seen through the exhaust duct).

Photo 12. Deformation seen on the landing skids.

2.5.2 TAILBOOM AND FENESTRON

The tailboom separated from the main fuselage at its primary attachment point. The right side of the tailboom exhibited a large, 45° impact mark approximately 23 inches from main fuselage separation point and was matched to an impact by the red main rotor blade. The right horizontal stabilizer exhibited impact damage adjacent to the leading edge approximately 20 inches from its outboard end. The left horizontal stabilizer exhibited no substantial damage.

The Fenestron had fractured and separated from the tailboom at the tailboom's aft ring frame; the fracture surfaces exhibited signatures consistent with overstress failure. The lower structure of the Fenestron and the tail skid attachment exhibited multiple fractures consistent with ground impact damage. The tail skid was bent upward consistent with hard impact to the ground resulting in the tail skid ground scar. An impact line along the right side of the Fenestron was observed from the aft side of the Fenestron adjacent to the Fenestron weight, through the Fenestron stators, and to the forward side of the Fenestron; the impact damage was later matched to damage found on the tip end of the 'blue' main rotor blade (**Photo 3**). The weight at the aft end of the Fenestron was found separated from the Fenestron.

3.0 ENGINE RUN AT TURBOMECA

The engine was removed from the aircraft and transported to Turbomeca in Grand Prairie, TX. On January 30, 2013 the NTSB IIC; Airworthiness Group members from Turbomeca, AEC, and the

FAA Rotorcraft Directorate; and representatives from Air Methods convened at Turbomeca to perform an engine run and a readout of the DECU. On the test stand, the engine experienced tailpipe fires during initial runs due to a jam in the fuel valve within the HMU. The HMU was replaced and subsequently the engine operated normally to approximately 100% RPM. A distinct whining noise was heard at idle, consistent with deformation damage observed on the first-stage axial compressor blades. The original HMU was bench tested and the fuel valve was cycled to the close position when commanded. Attachment 1 contains the engine examination report from Turbomeca.

4.0 ENGINE TYPE CERTIFICATE DATA SHEET (TCDS)

TCDS Number E00054EN (Revision 8 dated July 15, 2011) for the Turbomeca Arriel engine states that the engines have not been tested to evaluate the effects of foreign object ingestion other than rain water (reference Note 6 of the TCDS). The TCDS further states that "the helicopter air intake design shall be such to prevent instantaneous ingestion of ice, snow, and water in excess of maximum quantities defined in the Installation and Operating Manual. A protective grid, as defined in the Installation and Operation Manual shall be installed to limit the ingestion of foreign matter in the engine." Attachment 2 contains TCDS Number E00054EN.

5.0 MAINTENANCE

5.1 AIR METHODS INSPECTION REQUIREMENTS

According to Air Methods, the aircraft was parked outside and exposed to low temperatures and precipitation on December 31, 2012[3], two days prior to the accident. The air filter cover was not installed at that time. The following day, January 1, 2013, the air filter cover was installed; the aircraft remained parked outside and exposed to low temperatures[4]. On the morning of January 2, 2013[5], the aircraft logbook stated an airworthiness check was performed by the mechanic in accordance with EC130 B4 AAIP, but the "confirm your aircraft" (CYA) was not signed off.

An EC130 B4 Preflight/Airworthiness Checklist (Revision 4 dated December 19, 2012) was found in the accident helicopter. The checklist contained a list of exterior checks to be performed at five different stations around the helicopter. One of the checks for station 2 stated "Engine air intake – Clear (water, snow, foreign object)." There were no additional notes associated with the check for the engine air intake. Attachment 3 contains a photograph of the Air Methods EC130 B4 Preflight/Airworthiness Checklist found in the accident helicopter.

5.2 INSPECTIONS FOR OPERATING IN COLD WEATHER CONDITIONS

The Eurocopter EC130 B4 Aircraft Maintenance Manual (MET) 05-40-00, Section 6-3 (dated July 4, 2012) contains instructions on procedures to take before flight in cold or extreme cold weather conditions. These instructions include a step to "manually and visually check for

[3] According to METAR data from KSNL, on December 31, 2012 the temperature ranged from a low of 36°F (dew point of 36°F) to a high of 43° F (dew point of 43° F).

[4] According to METAR data from KSNL, on January 1, 2012, the temperature ranged from a low of 32°F (dew point of 30°F) to a high of 41°F (dew point of 41°F). The high temperatures were recorded in the early morning hours of the day with the temperature trending downward as the day progressed.

[5] According to METAR data from KSNL, on the morning of January 2, 2012, the temperature was at a low of 27°F (dew point of 27°F).

snow and ice inside the air intake duct up to the first stage of the compressor." Attachment 4 contains MET 05-40-00, Section 6-3.

FDC/aerofilter's Rotorcraft Flight Manual Supplement (RFMS) 1130-1200 (Revision B dated for EC130 B4 aircraft equipped with an FDC/aerofilter inlet barrier filter system contains a list of exterior checks to perform prior to the first flight of the day or prior to each flight if snow or freezing rain has fallen. The check for the engine cowling states "verify air intake to be free of snow, ice, or water, particularly under the filter." Attachment 5 contains the inspection requirements published in FDC/aerofilter's RFMS 1130-1200 Revision B.

5.3 NOTICES RELATED TO OPERATING IN COLD WEATHER CONDITIONS

Eurocopter released Information Notice No. 2302-I-00 (Revision 0 dated April 5, 2011) regarding engine flameout or damage when the aircraft had previously been subjected to cold weather in snowy or rainy conditions and parked in the open. The Information Notice states that "a turbine engine is susceptible to a 'sudden quantity' of water, snow, or ice, because this quantity (even limited) corresponds to a very high instantaneous concentration exceeding its absorption capacities." The Information Notice contains recommendations for the prevention of this issue and precautions to be taken in cold weather when temperatures are close to or below freezing (32° F or 0° C). Attachment 6 contains Information Notice no 2302-I-00.

The FAA released SAIB SW-08-03R2 (dated January 15, 2010) regarding in-flight loss of engine power due to snow or ice ingestion. The SAIB describes that snow or ice can accumulate in the engine intakes and plenums while the aircraft is on the ground with the engine(s) not operating or at a low power setting for an extended period of time. When the pilot increases the engine power during takeoff, the accumulated snow and ice can separate from the engine air inlet and be ingested by the engine, resulting in a decrease in power or a complete loss of engine power. The SAIB also contains recommendations for the prevention of this issue.

6.0 CORRECTIVE ACTIONS

Due to the findings from this investigation, Air Methods released a message on their 411 notice system that required acknowledgement by all pilots. The message contained information specific to engine operations in cold weather conditions and a pre-flight precaution to inspect the accessible internal surfaces of the engine air intake area, regardless of whether the engine air intake was covered.

On January 17, 2013 the FAA released SAIB SW-08-03R3 (Revision 3) with updated information regarding recommendations and precautions to take for rotorcraft operation in icing and/or snowy conditions to prevent the in-flight loss of engine power due to snow or ice ingestion. Attachment 7 contains SAIB SW-08-03R3.